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DEVELOPMENT OF A MECHATRONIC BLIND STICK

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Abstract: In this paper, few methods of guiding visually impaired persons are presented. There are analyzed some commercially available systems which help in locomotion people with disabilities of seeing and give information refereeing to the location of the users. We propose an “intelligent” stick equipped with an ultrasonic sensor that takes information about the environment. This information is processed and is delivered to the handle stick and thus can be interpreted by the users.

1. INTRODUCTION

The importance of sensorial and communicational functions results from the fact that the human body is an open biosystem, in a permanent exchange of energy, substances and information with the environment. The human being receives information from the environment: 1% by taste, 1,5% by tactile sense, 3,5% by smell, 11% by hear and 83% by sight, [9].

For an efficient reintegration of the disabled people in the family and society, it is strongly needful to assist their diminished functions or to replace the totally lost functions. Thus, a new branch of technology and engineering is developing: *Assistive Technology*, meaning any product, instrument, equipment or technical system used by a disabled person, especially produced or generally available, preventing, compensating, relieving or neutralizing the impairment, disability or handicap, [3], [8].

Visual impairment refers not just to a total blindness, but to a more common problem of partial or low vision. It is caused by many different conditions conducting to a variety of perceptual problems: macular degeneration reduces clarity of central vision, advanced retinitis pigmentosa produces a “tunnel” vision, cataracts cloud or blur images, diabetic retinopathy produces overall dimness, blank or unclear areas, temporary or permanent, optic nerve atrophy superimposes coloured forms on an image, a.s.o. Because the problems of visual impairment are much diversified, the solutions for assisting or replacing the visual sense vary too.

The traditional and oldest mobility aids for persons with visual impairments are the walking cane (also called white cane or stick) and guide dogs. The most important drawbacks of these aids are necessary skills and training phase, range of motion and very little information conveyed.

The aim of this paper is to describe new methods of guiding visually impaired persons and to present a new low cost system, called “mechatronic blind stick” which is easy to use by visually impaired persons.

2. COMPARATIVE STUDY OF SIMILAR PRODUCTS

Several sophisticated guide systems for visually disabled have already been developed. These are based on following methods, [1], [10]:

- the equipment on the ground detects a magnet in the user’s cane and sends a guide message by a speaker;

- a sensor in the cane detects magnets on the ground and informs the user by vibration;
- a specialized system on the ground detects the signal from a portable transmitter of the user and sends a guide message by a speaker;
- the radio carried by the user catches the broadcasting messages transmitted through an antenna installed in the ground;
- a portable system informs the user of his/her position using GPS signal.

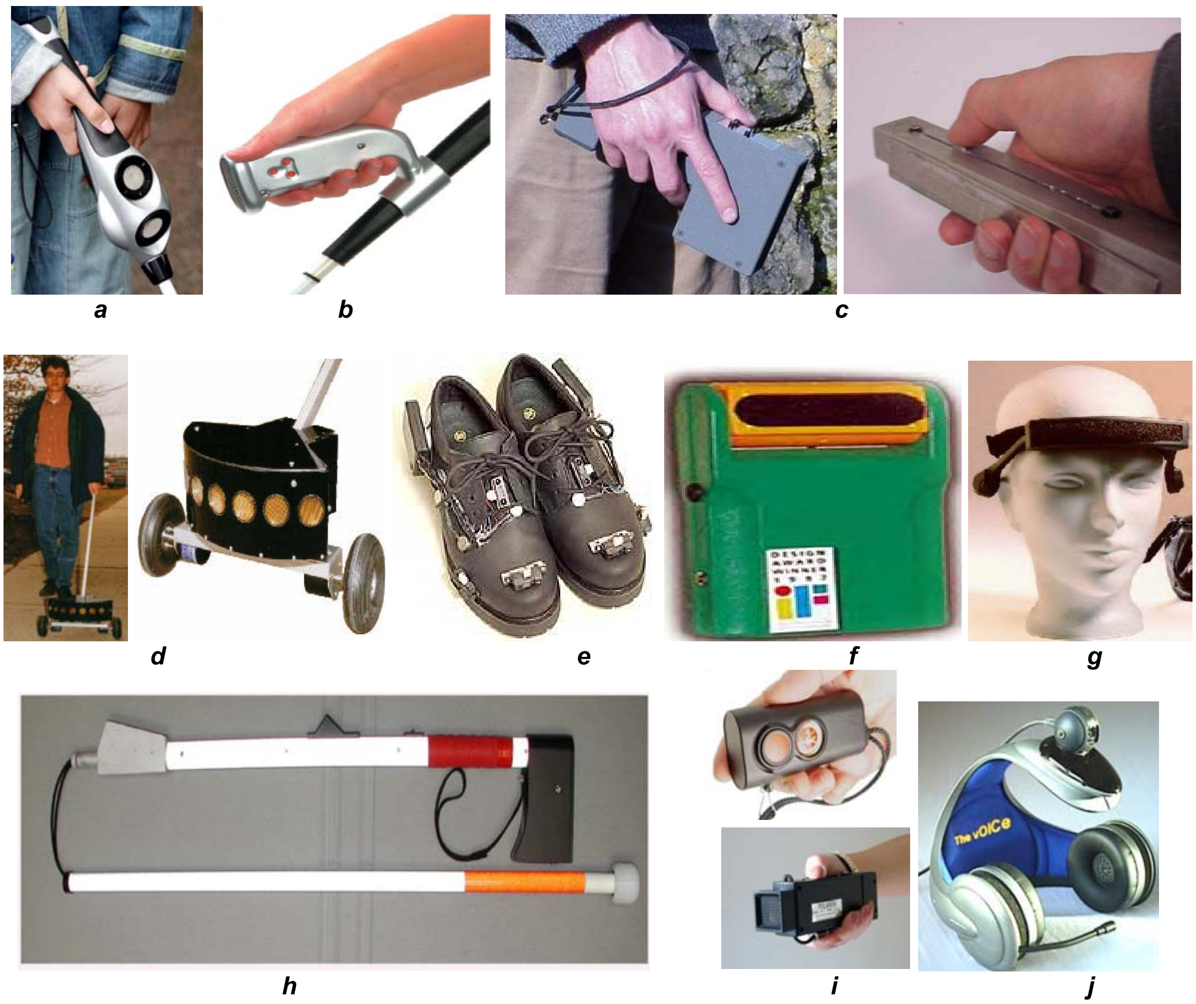


Fig. 1 Examples of representative mobility aids vor visual impaired persons

New mobile guide systems that utilize the latest technologies such as data-carriers, mobile communication and portable computers are experimentally tested. Coded data recorded in data-carriers are transferred to visually disabled users via a reader in the cane; the data are interpreted by a portable computer, which generates guide messages via a portable speaker. For safety of the visually disabled passengers, several systems that offer guide messages using speakers installed at fixed places are already in use, but these messages are fixed and not adaptive.

According with [2], [4] - [7] and [12] - [18], in Figure 1 there are presented some representative commercially available products designed as mobility aids and guiding systems for visually impaired persons.

The *UltraCane* (Fig. 1a) is a vibrating electronic mobility aid and obstacle detector. The cane has the shape of a long white cane with a collapsible shaft and a contoured handle, and uses ultrasonic echos to detect obstacles ahead of the user, including obstacles in the user's path and at head level. It converts this information into vibrating buttons in the handle which tell the user where an object may be and how far away the obstacle lies. The cane can be customized to the user's height.

The *'K' Sonar* (Fig. 1b), is an audible electronic mobility aid and obstacle detector. This small electronic device aids users who are blind or visually impaired with orientation and mobility. By listening to sounds produced by the device, users can determine the distance and location of objects and some of the object's features. The device attaches to the golf grip handle of a long cane. Headphones provide audio feedback, which changes in pitch to indicate the distance to the object being scanned.

The *Teletact* is a hand held laser telemeter (Fig. 1c). The distance to the first obstacle encountered by the laser beam is measured with about 1% accuracy in the 10cm – 10m range. The blind perceives the direction he points thanks to the internal consciousness of the position of its members (proprioception). To identify an obstacle it is necessary to scan the environment. So, the rate of distance measurements is 40 measurements per second. To communicate to the blind the information of distance, 28 different musical notes are used, which correspond to 28 unequal intervals of distances (intervals are smaller at short distances), the higher the tone, the shorter the distance. The telemeter gives a precision of about 1% on the distance measurement. The most important information is not identification of musical notes but the sense and the rate of their variations, in other word the transcription of the profile of the obstacles into a “melody”. To obtain a silent device the sonorous output is replaced by vibrating devices localised under the fingers.

The shoes in Figure 1e are equipped with infrared sensors that sense objects up to a meter away and trigger vibrations corresponding to the location and size of obstacles.

The *UBG - Ultra Body Guard* (Fig. 1f) is a vibrating and voice output electronic mobility aid which detects obstacles at head and upper body level and provides users with tactile or spoken warnings.

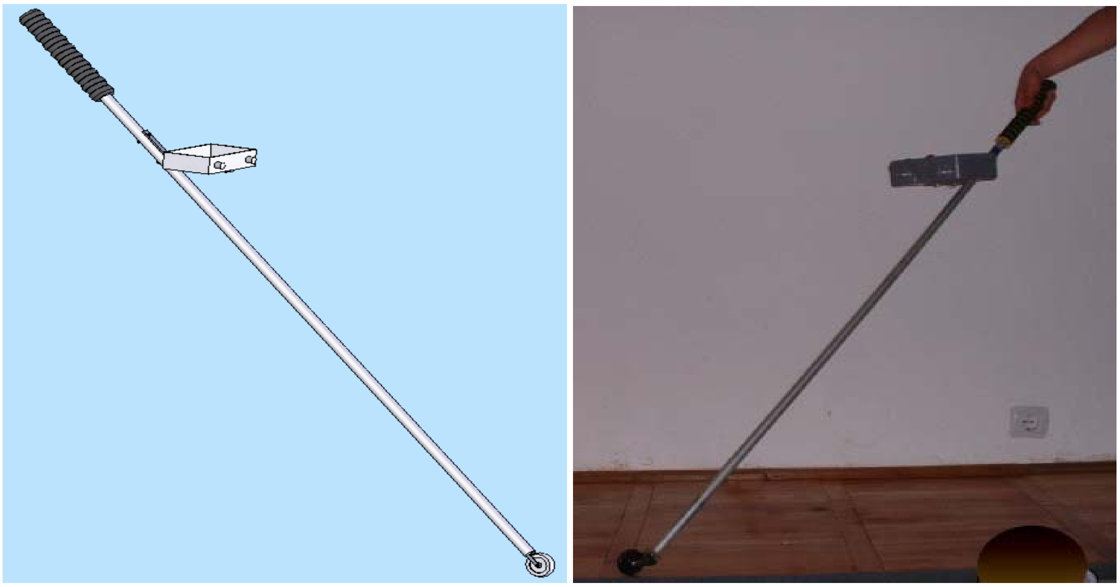
The *Sonic Pathfinder* (Fig. 1g) is an electronic obstacle detector which gives the user advanced warning of objects which lie within his or her travel path. It is a head-mounted pulse-echo sonar system controlled by a microcomputer, with five ultrasonic transducers mounted on a headband, comprising two transmitters and three receivers, one pointing left, one right, and one straight ahead. Echoes from objects are received by the three receiving transducers and this information is processed by the on-board computer. The output is fed to one or other of the two ear pieces.

The LaserCane (Fig. 1h), warns the user of approaching obstacles through audible tones and vibrating stimulators under the index finger. The user has the option of turning the audible tones off to rely on the vibrating stimulators alone. The cane is used in the same manner as a long white cane. The cane is operated with one hand, while the other hand is free for other tasks.

Other systems are given in Figure 1: *The Guide Cane* (Fig. 1d), *Miniguide and Polaron* (Fig. 1i) and *The VOICE* (Fig. 1j). The apparatus composing the above presented systems are expensive and often places where they are installed or could be used are restricted.

3. THE DEVELOPED SYSTEM

The new “intelligent” blind stick ensures an alternative channel for the sensorial perception (e.g. tactile sense and hearing, instead of seeing). It is made of a pipe 18 mm diameter. The pipe is divided in two parts, first has 630 mm length and the second has 720 mm. A plastic box is fixed on the upper part of the stick. Inside of this hull there are the ultrasonic sensors, the circuitry and the buzzer. The cane weights 450 g. In Figure 2 the 3D model and a picture of the stick are presented.



a ***b***

Fig. 2 The 3D model and a picture of the developed stick

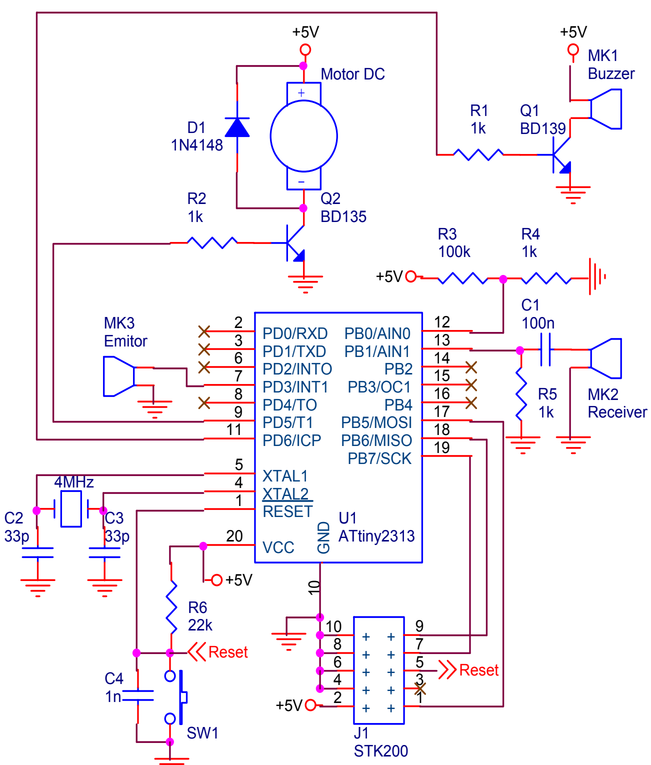
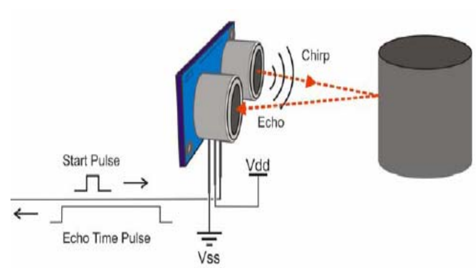


Fig. 3 The electrical diagram



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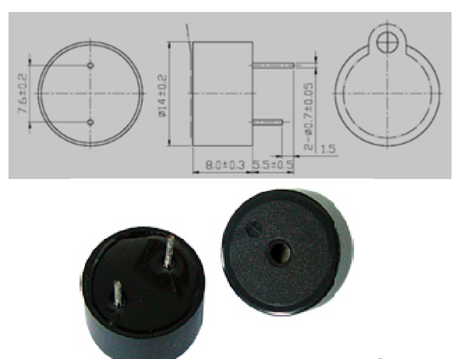

b

Fig. 4a – The ultrasonic sensors,
Fig. 4b The piezo buzzer

The distance from the sensor to an obstacle in front of the stick is detected by the ultrasonic sensors which we used: UST – 40 type (fig. 4a). These sensors are characterized by center frequency 40 kHz, whith a tolerance between ± 2 kHz and transmitting sound pressure level 120dB. The electrical diagram is presented in figure 3 and the circuit works as follows:

- it is activate the switch on/off ;
- it is sent the work frequency (f=40 kHz), three period, realized by timer 0 of ATtiny2313 microcontroller;
- therewith it is activate timer 1;
- at first echo impulse received the timer 1 it's off and the value (t) recorded it's used to calculate the distance using the relation:

$$d = \frac{vt}{2} \;, v = v_0 + 0.6T \tag{1}$$

where we note:
v_0 – the sound velocity at T=0°C, v_0=331.45 m/s
T – the temperature.

- the vibration of the handle is produced by a DC motor. We use PWM (Pulse Width Modulation) method to control the miniature DC motor. Width factor is proportional with the distance. In figure 5 there is presented the diagram for electric impulse.
- it's activated the sound alarm. The sound is more intense as the distance is smaller. The piezo buzzer CPB14B09 was used (Fig. 4b);

In figure 6, the layout circuit of this application is given.

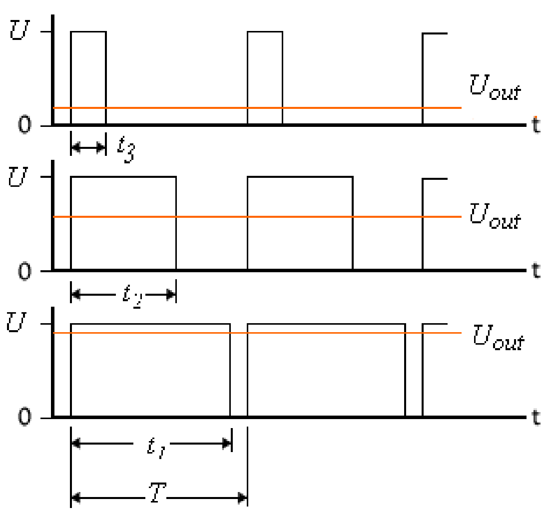

Fig. 5 The impulse diagram

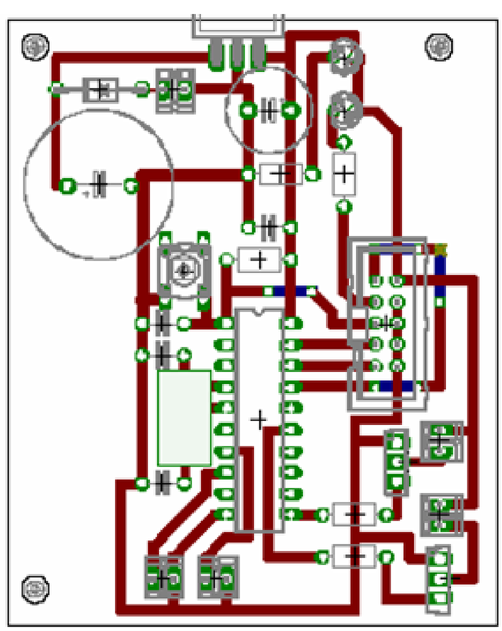

Fig.6 The layout circuit

CONCLUSIONS

The assistive devices are much diversified due to the diversity of affections, having a strong adaptability to each user. The visually impaired persons, especially the blind people, gather information from the environment through the other valid senses (tactile and hearing sense). One of the improvements which can be brought to classical white canes is to equip them with proximity sensors and systems which can be used to transmit information shaped like acoustic and tactile signals.

The developed prototype gives good results in detecting obstacles paced at distance in front of the user. Our efforts are focussed on improving the output signals (vibrations and sounds), according with the distance.

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[13]. * * * Polaron http://www.abledata.com/abledata.cfm?pageid=19327&top= 15688 &productid = 95519 &trail=0
[14]. * * * Sonic Pathfinder http://www.abledata.com/abledata.cfm?pageid=19327&top =10267&productid= 746 26&trail=0
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